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Spring Wheat in Minnesota

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IN the early history of Minnesota, the incoming settlers, as in all newly developed agricultural sections, devoted the greater part of their cultivated land to the production of grain crops. Spring wheat proved a valuable cash crop and in many sections no attempt was made to grow other crops. Wheat followed wheat with clock-like regularity. With the advancement of knowledge concerning the suitability of other crops, the trend has been toward a definite decrease in spring wheat production. In view of the present wheat surplus and the prospect of low prices for some time to come, Minnesota farmers should give serious consideration to the advisability of further curtailing the wheat acreage. In southern Minnesota there will be no difficulty in replacing wheat with other crops that will bring even greater returns. In the Red River Valley and in west central Minnesota it will not be so easy immediately to replace wheat with more profitable crops because of the larger farm acreages and the greater difficulty of maturing the corn crop.

Crop rotation is essential, and the growth of legumes and the introduction of livestock are desirable in a system of permanent agriculture. A proper crop rotation aids in controlling weeds, whereas legumes and livestock assist in maintaining soil fertility. The successful spring wheat producer now follows a definite rotation and in many cases has added livestock in some form as an important farm enterprise. With the increased acreages of corn, barley, winter wheat, flax, and other crops, less land has been devoted to spring wheat. This has resulted in a marked change in total production, as shown by data taken from the United States Department of Agriculture Yearbooks.

Table 1

Average Annual Acreage and Production of Spring and Durum Wheat in Minnesota by Ten-Year Periods, 1871-1929

Year	Acreage	Bushels
1871-1880	1,896,000	26,224,000
1881-1890	2,969,000	36,930,000
1891-1900	3,766,000	52,512,000
1901-1910	5,101,000	68,312,000
1911-1920	3,726,000	50,131,000
1921-1929*	1,672,000	22,171,000

* Nine-year average.

CLASSES OF WHEAT GROWN

Three general classes of wheat are grown in Minnesota: Winter, hard spring, and durum. Of these, hard spring wheat is the most desirable for bread flour because of its high protein content. The desirable characteristics of this class have made the spring wheat area famous as the home of a flour of high quality. The protein of wheat gives flour the tenacity that allows bread to rise to a large volume with consequent lightness. Spring wheat flour is often mixed with winter wheat flour to raise the protein content of the latter. No varieties of

winter wheat are sufficiently hardy to be grown successfully in the Red River Valley, a section where spring wheat production is a major enterprise (Fig. 1).

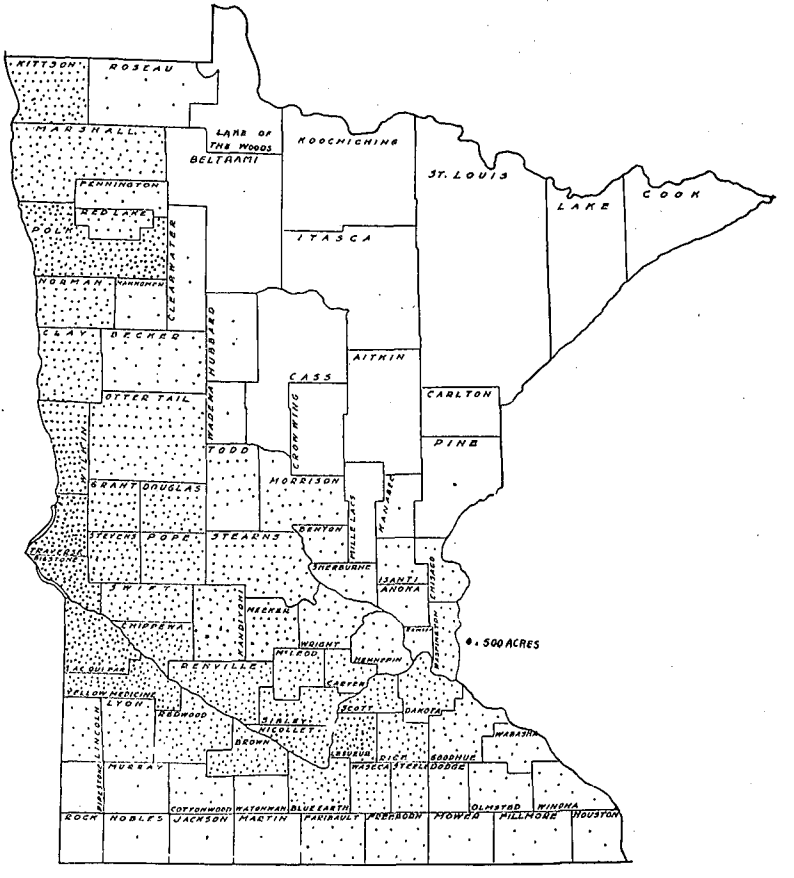

Fig. 1. Acres of Spring Wheat Other Than Durum Grown in Minnesota in 1929 Each Dot Represents 500 Acres.

The Minnesota River Valley and surrounding territory produces much spring wheat. In this section there is greater competition with other crops, and winter wheat also can be grown successfully. Many of the farmers south of Stevens County would probably find the production of winter wheat more profitable than that of spring wheat.[1]

Durum wheat is used for the manufacture of semolina, a coarse flour from which is made macaroni, spaghetti, vermicelli, noodles, and similar products and some breakfast foods. It has been grown in the Red River Valley, largely because of its higher yield and greater re-

[1] Hodgson, R. E. and Hayes, H. K. Winter Wheat Varieties—Importance and Culture. Minn. Spec. Bull. 127. 1929.

sistance to stem rust than the hard spring wheat varieties available. The acreage of durum wheat in southern Minnesota is limited because it is difficult to produce good durum in that section.

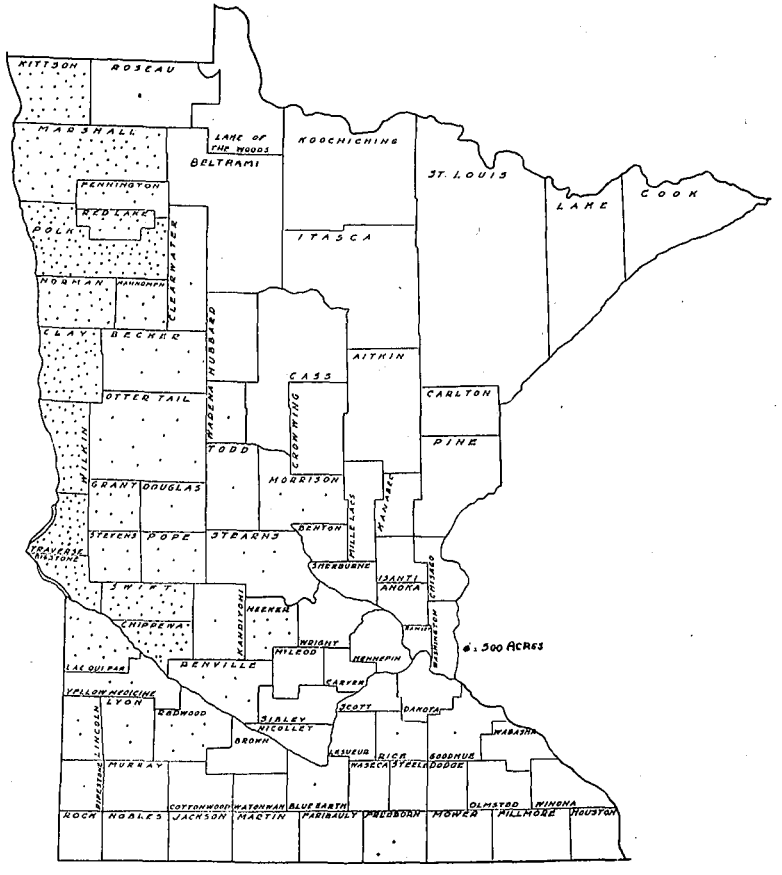

Fig. 2. Durum Wheat Grown in Minnesota in 1929
Each Dot Represents 500 Acres.

HARD SPRING OR DURUM WHEAT

The prices of durum wheat are generally less than those of hard red spring wheat, largely because of the wheat's lower grade. There are two general types of durum, amber and red. Pure amber commands a premium. Starchy kernels reduce the value because they lower the quality of the semolina and the semolina products. Variety, soil, and climate influence the color and texture. All red durums are unsuited for semolina manufacture and amber varieties differ in quality. The soils and climate in the Red River Valley are generally favorable for the production of amber durum.

To command a premium on the market, durum wheat must be of superior quality, and must not be mixed with hard spring wheat. Such mixtures are practically inseparable and seriously interfere with milling processes. Barley in durum wheat is also objectionable. If durum wheat is of the color, texture, and purity demanded, it has a ready market at a good price, in the Red River Valley.

The efforts of European governments to encourage domestic wheat production by bounties and tariffs has reduced the export of durum wheat, hence there is less export demand for durum wheat of poor color and for mixed durum. The home consumption of macaroni products, however, is increasing and there is a good foreign demand for grain of high quality. In years of stem-rust epidemics, the yields of durum have been greatly superior to those of susceptible spring varieties, such as Marquis. Durum varieties are grown frequently, partly as insurance against severe losses from stem rust. With the development of rust-resistant types, spring varieties of bread wheat yielding on a par with the better durums will be available. (Table 2).

Table 2

Average Yields per Acre of Recommended Varieties of Spring and Durum Wheat at Different Locations in the State, 1925-29

Variety	Minn. No.	University Farm	Waseca	Morris	Crookston
		bu.	bu.	bu.	bu.
Marquis	Acc. No. 1239	25.7	24.0	19.1	24.1
Marquillo	2202	28.5	22.7	23.3	31.1
Ceres	Acc. No. 2223	30.6	25.1	20.6	28.4
Mindum (Durum)	470	30.4	28.9	28.5	33.5

IS SPRING WHEAT PROFITABLE

During the five years, 1924 to 1928, the cash value of spring wheat made it one of the best grain crops for Minnesota farmers. The figures in Table 3 show the relative acre yields and values of the more important Minnesota grain crops for the 5-year period 1924-28.[2] These data indicate that spring wheat, though outranked in acre value by winter wheat, corn, and flax, is still an important cash crop in some regions of this state. By proper seed selection and cultural practices, Minnesota farmers may realize fair returns on production in areas where it is still advisable to grow spring wheat.

[2] Bulletins 63 and 65, Minnesota Annual Crop and Livestock Statistics. Paul H. Kirk. Published by Minnesota State Department of Agriculture.

Table 3

Average Yields and Values per Acre Based on December 1 Price of Other Small Grain Crops and of Corn in Comparison with Spring Wheat, 1924-28

Crop	Yield	Value
	bu.	
Winter wheat	19.6	$23.33
Flax	9.6	20.46
Spring wheat	14.6	17.56
Barley	29.4	16.99
Rye	16.3	14.28
Oats	35.6	13.01
Corn	32.5	20.67

DISEASES OF SPRING WHEAT

Plant diseases cause tremendous losses of wheat. Some of these losses are unavoidable, altho knowledge of the life history of a disease and the intelligent use of adequate control measures will do much to reduce the damage.

Stem rust is the most destructive cereal disease in the spring wheat area. In Minnesota, it lives over winter as spores in black spots on old straw and stubble. It is never carried on or in the kernel. In the spring the rust spores germinate and are blown to the common barberry bush, where they cause orange-colored spots on the lower surface of the leaves. These orange spots contain a new type of spore, which can infect wheat and other grains and grasses, resulting in the so-called "red rust." This appears as brick-red spots on the leaf sheaths and stems of the wheat plant. These spots are often confused with the orange pustules (rust spots) of the less injurious leaf rust. Stem rust may be distinguished readily from leaf rust as the stem rust fungus practically always breaks the outer layer of the stem and later in the season black spores are formed on the stem in the spots bearing the red spores. These have thick-walled cells, with the ability to live through the winter and germinate the following spring again to attack the common barberry and thus complete the life cycle.

Stem rust attacks wheat, rye, oats, barley, timothy, redtop, and about twenty species of wild grasses. However, wheat stem rust will not infect oats, nor will oats stem rust attack wheat. Rye stem rust will not attack oats or wheat. Both wheat and rye stem rust will attack barley and many wild grasses. Oats rust may infect many wild grasses.

Seed treatment is useless for control of stem rust. The following practical methods for reducing losses are suggested: (1) Grow rust-resistant varieties. Marquillo and Ceres are highly resistant, also nearly all durum varieties. (2) Destroy the common barberry. (3) Sow wheat as early as possible.

Orange leaf rust is the common leaf rust of wheat. It is often confused with the red spore stage of stem rust. Small, more or less circular, orange-colored pustules appear on the green leaves early in the season. Later, pustules appear on the leaf sheaths and on the leaves. Usually the pustules do not break the bark or cause sunken areas, as does stem rust. The rust destroys considerable leaf area and, in some seasons, causes marked reduction in yields. No practical control measures are known except to grow resistant varieties. Marquis and Marquillo are moderately resistant to leaf rust; Ceres and similar strains are very susceptible. Hope is highly resistant.

Bunt or stinking smut lives over winter as spores (seeds) on the outside of the wheat kernels or in smutted kernels (smut balls). The spores germinate in the soil near or on the wheat seed. The fungus then infects the seedling, grows up with the wheat plant, and fills the newly-formed kernels with spores. These break in threshing or in handling the grain and the spores cling to the outside of the kernels. Wheat containing smut balls or having a smutty odor sells at a discount.

Control of bunt consists in disinfecting the seed coat of the wheat kernels. Either of the two following treatments may be used:

1. Mix copper carbonate dust with seed wheat at the rate of two or three ounces of copper carbonate to each bushel of wheat. Mix thoroly in a machine made for the purpose. Do not attempt to mix by shoveling or by sifting upon seed in a drill box. Avoid inhaling the dust; it will cause discomfort and possible illness. Treated wheat is poisonous and must not be used for milling or feeding.

2. Treat with a formaldehyde solution made by adding one pint of 40 per cent formaldehyde to 40 gallons of water. Dip, sprinkle, or use a commercial seed-treating machine. Sow without allowing treated seed to dry. When allowed to become dry or where sown in a dry soil, some injury to germination may result. Treated seed must not be allowed to freeze. Copper carbonate is better than formaldehyde.

Loose smut appears in the field just as grain is heading out. Entire wheat heads are destroyed. Black masses of spores cling to the naked stem. These soon are blown away to other heads of wheat or washed to the ground by rains. This disease may reduce the yield but does not affect the quality of the grain produced.

The infection takes place at flowering time. Spores lodging on the flowers germinate and grow into the young developing grain. Kernels thus infected can not be distinguished from healthy grain. Within the seed, the disease-producing fungus lives over winter. In the spring when the grain is sown the fungus resumes its growth and keeps pace with the growing point of the wheat, destroying the head.

Copper carbonate and formaldehyde treatments are useless for the control of loose smut. The most practical control is to discard the infected seed and obtain new, healthy seed. If this is not possible, sufficient grain for a seed plot may be treated by the hot-water method.

The hot-water treatment is as follows: Place seed in loose burlap bags filled half full, and soak them in water at room temperature from 5 to 7 hours. Then immerse in hot water at 125 to 129 degrees Fahrenheit for 10 minutes. Hot water above 131 degrees Fahrenheit or immersed for a longer time than that specified will injure germination severely. Remove promptly, plunge in cold water to lower the temperature quickly, and spread at once in a thin layer on the floor to dry.

Seed treated with hot water should be sown in an isolated plot where it will not be infected by smut spores blown from fields containing loose smut. Marquis is resistant to loose smut; Ceres and Kota are susceptible.

Scab symptoms on wheat are most conspicuous and characteristic on the heads. Affected spikelets often appear to have ripened prematurely while healthy spikelets are still green. The glumes of diseased heads are often coated with a smooth pinkish, orange, or red mold. Infected kernels fail to develop properly and are usually very small, much shrunken, and can be crushed easily between the fingers. The amount of shrivelling varies with the severity of infection.

The seedling blights caused by scab resemble the injury caused by several other fungi. The plants are usually stunted, with reduced root systems having brown or pink rootlets that may decay quickly.

The organism causing scab is carried by the seed and may live in the soil indefinitely. As the fungus affects corn as well as wheat and multiplies abundantly on the residues of corn, wheat should not be grown on corn land containing the disease. Durum varieties are especially susceptible. Marquis, Ceres, and Marquillo are also susceptible. Haynes Bluestem and Preston are resistant.

Control measures consist in: (1) Grow resistant varieties; (2) practice crop rotation, avoiding the seeding of wheat following wheat; (3) clean the seed with a vigorous air blast to remove shrunken kernels; and (4) kill the spores on the outside of the kernel by the standard copper carbonate treatment, as previously described, for controlling bunt.

RUST-RESISTANT VARIETIES NEEDED

Marquis has been the standard high-quality spring wheat variety since its introduction into Minnesota in 1912. It has, however, had one outstanding undesirable character—susceptibility to black stem rust. This has led to an attempt to breed varieties having the milling qualities of Marquis coupled with disease resistance.

For many years the plant breeders and plant pathologists of the Minnesota Agricultural Experiment Station, co-operating with the Bureau of Plant Industry, United States Department of Agriculture, have been studying the possibility of obtaining an improved hybrid variety. From 1908 to 1914 the only available stem-rust-resistant varieties belonged to the durum group. Accordingly, in 1914 Marquis, used as a female parent, was crossed with Iumillo, a durum wheat, as a male, or pollen-bearing, parent. Extensive selections were made and one was named Marquillo and increased for distribution. This variety has proved to be high yielding and to possess marked resistance to black stem rust. It is awnless, resembling Marquis in head type, but has shorter straw. In kernel type, stiffness of straw, and time of maturity, Marquillo also resembles its Marquis parent. Its very stiff straw makes it a suitable companion crop for small-seeded grasses and legumes and also for use on summer fallow or potato land where lodging is a factor.

In baking trials made by the Division of Agricultural Biochemistry from 1922 to 1929, Marquillo has milled flour which, when baked, produced a loaf of bread of good quality and texture. There is a tendency to a yellow color. Through the use of bleaching agents the miller can remove the yellow color without injuring the loaf volume or texture of the bread. This yellow color may result in a discount in price. Increased yield, however, will tend to offset a possibly lower price. Marquillo was first introduced in 1929 to a list of approved growers.

PLACE OF CERES IN MINNESOTA

Ceres, a bearded bread wheat produced by the North Dakota Agricultural Experiment Station from crossing Marquis with Kota, is highly resistant to stem rust but very susceptible to leaf rust, loose smut, and bunt. Seed should be treated for bunt with copper carbonate or formaldehyde and if the seed is infected with loose smut it may be necessary to use the hot-water treatment. The straw is not so strong as that of Marquis but stiffer than that of Kota. In milling and baking qualities it is about equal to Marquis. The yields of Ceres have excelled those of Marquis (Table 2). It is better adapted to southern Minnesota than Marquillo. Ceres was first distributed by the North Dakota Station in 1926 and in Minnesota in 1927.

IS MARQUIS TO BE DISCARDED?

Marquis is a selection from a cross between two hard red wheats known as Hard Calcutta and Red Fife. The cross was made in 1892 under the direction of William Saunders, Ottawa, Canada, and the selection was made and named by C. E. Saunders, Dominion cerealist. It has been an outstanding variety in Minnesota, and were it not for

its susceptibility to black stem rust and scab it probably would be the best variety of spring wheat for the northwest. However, because of losses from stem rust, this variety may be replaced in the future by disease resistant varieties.

IMPORTANT VARIETIES NOT RECOMMENDED

Burbank's Quality is an awnless, white-grained hard wheat produced by Luther Burbank. It heads out 7 to 10 days earlier than Marquis but ripens only 2 to 4 days earlier. In the trials at University Farm, Waseca, Morris, and Crookston for a three-year period, Quality yielded only 19.3 bushels compared to 21.0 bushels for Marquis. It is not rust-resistant, and not always early enough to escape rust. In milling and gluten tests at various experiment stations it has not met the standard requirements.

Reward was developed from a cross between Marquis and Prelude, made in 1912 at Ottawa, Canada. It matures 3 or 4 days earlier than Marquis and has a very fine appearing kernel. In a three-year trial at the four spring wheat testing stations, Reward has out-yielded Marquis by one-half bushel and the bushel weight of the grain has averaged 3 to 4 pounds more. It is an awnless, hairy-chaffed wheat similar to Marquis in head type. It is not rust-resistant and will not mature early enough in some seasons to escape rust. It is preferred to Marquis by some growers because of its earliness and high weight per bushel.

Garnet is a Canadian variety developed by crossing Preston and Early Riga. It matures about one week earlier than Marquis or about the same as Ruby. The heads are awnless. It is not rust-resistant. Flour made from Garnet has a distinctly yellowish color. In three-year trials at University Farm, Waseca, Morris, and Crookston, it has yielded 2 to 6 bushels less than Marquis.

Supreme is a Canadian selection from Red Bobs. It is awnless and resembles Marquis in height and maturity. It has been tested one year in Minnesota, and is susceptible to both stem and leaf rust.

Hope is the result of a cross of Marquis and Yaroslav emmer made by E. S. McFadden, Webster, South Dakota, in 1920. It is extremely resistant to stem and leaf rust. In preliminary baking trials, it has appeared to have good milling qualities. It is a bearded variety with strong straw slightly shorter than that of Marquis, and matures about the same time. It has not been tested thoroly for yield in Minnesota but two years' results indicate yields similar to those of Marquis. It is resistant to bunt and scab but very susceptible to black chaff, a disease which can be controlled only by growing resistant varieties.

WHAT DURUM VARIETY IS BEST?

Mindum, an amber durum, is unquestionably the best variety for the Minnesota farmer who wishes to grow durum wheat. In resistance to stem rust it ranks high. It was developed through selection by the Minnesota Agricultural Experiment Station and to a considerable extent has replaced other durum varieties in the state. It makes the highest quality of macaroni. Mindum, like other durum wheats, however, is subject to lodging on summer fallow and potato land.

Kubanka is an amber durum that shows considerable resistance to stem rust, tho susceptible to some forms of stem rust. It makes excellent macaroni. In a five-year trial at the Northwest station, it yielded 3.7 bushels an acre less than Mindum. It was introduced from Russia in 1900 by M. A. Carleton, of the United States Department of Agriculture.

Pentad, also known as D-5 and Red Durum, is very resistant to stem rust and yields more than standard varieties in seasons when se-

Fig. 3. Field Plot of Mindum Wheat in Varietal Trials. University Farm

vere epidemics of stem rust occur. It makes very poor macaroni, however, and a mixture of this variety with amber durum lowers the grade and makes an undesirable market product. Pentad should be eliminated from the wheat-growing sections of the state. It was introduced into North Dakota from Russia in 1903.

Nodak is an amber durum variety, the result of a selection from Kubanka, by R. W. Smith of the Dickinson, North Dakota, substation. It is less desirable for macaroni than Mindum and yielded less than Mindum and Kubanka in 1929, the only year in which it has been tested extensively in Minnesota.

Table 4

Comparative Average Yields of Durum Wheat Varieties for the Three-year Period, 1919-21

Variety	Minn. No.	Univ. Farm	Crookston
		bu.	bu
Mindum	470	23.3	26.0
Arnautka	Acc. No. 2103	20.8	19.2
Acme	Acc. No. 1967	18.3	18.1
Kubanka	Acc. No. 2102	...	20.8
Pentad	Acc. No. 1968	...	21.8

CULTURE OF WHEAT

Place in Rotation

Hard red spring wheat varieties are, as a rule, ideal companion crops for small-seeded grasses and legumes. Durum varieties are not so desirable because of generally weaker straw. The grass crop may be drilled in with the wheat at the time of seeding or it may be broadcast on the surface and covered by dragging or rolling the land. As wheat does not draw as much water from the soil as oats, it offers less competition to the grass crop. The narrow leaves of wheat shade the ground less than the leaves of oats or barley. However, spring wheat may be seeded too early to make it suitable for a companion crop with alfalfa. Where grown as a companion crop with grasses or legumes, only stiff-strawed varieties should be used, to avoid danger of lodging and smothering out the grass stand.

Where wheat may be expected to result in an important cash crop, it should be given a favorable place in the rotation. Particularly in the Red River Valley, when it follows sweet clover, increased yields of grain of higher protein content often result. Also, better control of weeds reduces the dockage of market grain. Summer fallow, potato, sugar beet, and corn land are all suitable for wheat if stiff-strawed, rust-resistant varieties are used. Such land tends to delay maturity, and increases the hazard from rust. If the soil is heavy, considerable lodging may occur. Such early, short-strawed varieties as Ruby and Reward have found favor for this reason. Altho Marquillo matures later it is rust-resistant and has short, stiff straw.

Soils and Fertilizers

Spring wheat does best on fertile clay loam soils. It requires as thoro seedbed preparation as corn. The soil should be well pulverized, firmed, and moist. Undecomposed vegetable matter interferes more with wheat production than with oats or corn.

Sweet clover, plowed under the preceding fall and the land well worked in the spring, is especially favorable for wheat. The advantage in protein content when wheat follows sweet clover is apparent from data furnished by the Polk County Farm Bureau, Table 5. In eleven comparisons of the same variety of wheat on the same farm, the crop produced on sweet clover land contained an average of 13.57 per cent protein, whereas that following various other non-leguminous crops averaged 12.36 per cent. Spring wheat grown on 66 fields of Polk County farms in 1929 contained 12.60 per cent protein when following non-leguminous crops. Thirty-one fields in the same county averaged 13.56 per cent protein when the wheat followed sweet clover.

Table 5

Protein Content of Wheat Following Sweet Clover and Other Crops, Polk County, Minnesota, 1929

Variety	Preceding crop	Protein, per cent	Preceding crop	Protein, per cent
Marquis	Corn	13.05	Sweet clover plowed under	15.30
	Corn	11.10	Sweet clover	11.60
	Barley	13.30	Sweet clover pasture	14.49
	Corn and potatoes	13.40	Sweet clover pasture	14.40
	Timothy	12.70	Sweet clover pasture	14.40
	Wheat	12.50	Sweet clover pasture	12.60
	Summer fallow	13.30	Sweet clover	15.15
	Wheat	11.70	Sweet clover pasture	13.10
Mindum (durum)	Potatoes	11.40	Sweet clover	13.60
	Oats	9.60	Sweet clover pasture	11.20
	Oats	13.50	Sweet clover	13.50
Average		12.36		13.57

In a one-year trial at the Northwest Experiment Station, Mindum produced 26.7 bushels of grain having 12.15 per cent protein and weighing 53 pounds per bushel when following sweet clover. The same variety yielded 24.5 bushels per acre following barley. The protein content was 10.65 per cent and the bushel test weight, 50.5 pounds.

If phosphatic fertilizers give a beneficial effect on clover or alfalfa, they should be tried on wheat. Where phosphate shows a beneficial effect on wheat, earlier maturity, and less stem rust injury may be expected. One hundred pounds of treble superphosphate containing from 45 to 47 per cent of phosphoric acid, or 225 to 235 pounds of 20 per cent superphosphate are the recommended rates per acre.

Preparation of Seed for Planting

It is a popular belief that wheat seed ultimately "runs out" and new seed from outside sources must be secured. Protein content may be influenced greatly by climatic and soil conditions. Also, it is influenced by heredity. Within a variety, however, seed with high protein content is no more valuable for planting than seed of the same variety but with a lower protein content. Environmental variations of this sort are not inherited and the theory that wheat runs out has been proved false. Planting seed from localities where the protein content was high does not increase the protein in the wheat raised.

One who obtains seed of a recommended variety from a grower of certified seed has little need for special seed preparation except to treat for smut. The farmer producing his own seed, however, should clean the seed thoroly with a good fanning mill. If mixtures with other varieties and inseparable mixtures of other grains or noxious weeds occur in considerable amounts, it is best to purchase new seed. If the seed is pure for variety, it is especially important to remove all weed seeds and light, chaffy grain. Diseased kernels are usually shrivelled and for the most part may be removed by fanning. A germination test should be made if there is any doubt regarding viability.

Early Seeding Essential

Early seeding of spring wheat insures good yields of high quality grain. Seedings should be made as early in the spring as it is possible to seed the crop. The seedlings will withstand considerable cold with little or no damage. Early seeding affords an opportunity for greater stooling and enables the plant to make the most use of the cool early summer weather. This tends to lead to early maturity, which helps to prevent damage from rust and promotes the development of high quality grain. The average date of seeding for a ten-year period at Crookston was April 16; at Morris, April 12.

Table 6

Average Yields per Acre of Marquis and Mindum Wheat Sown at Different Dates, University Farm, 1920-22*

Variety	Date of seeding	Yield per acre	Decrease from usual date
		bu.	bu.
Marquis	Usual date†	28.2	...
	10 days late	17.8	10.4
	20 days late	11.4	16.8
	30 days late	4.8	23.4
Mindum	Usual date†	32.6	...
	10 days late	22.3	10.3
	20 days late	7.4	25.2
	30 days late	1.8	30.8

* Data from A. C. Arny.

† Earliest date at which seeding could be made. Average, April 24.

Seed 75 to 90 Pounds per Acre

As seed represents but a small part of the spring wheat enterprise, no farmer can afford to err in the seeding rate. The seeding of 90 pounds per acre is sufficient for giving a good stand under normal soil conditions. The farmer who is willing to test his seed and to prepare the seedbed thoroly can sow seed at a reduced rate. The use of 75 pounds to the acre has been sufficient under ideal conditions (Table 6), altho 90 pounds is recommended for average conditions.

Table 7

Yields of Hard Spring Wheat Seeded at Different Rates, Crookston 1919 and 1923

Rate of seeding per acre	1919	1923	Average
lb.	bu.	bu.	bu.
45	9.9	17.4	13.7
60	13.3	19.6	16.5
75	13.2	27.0	20.1
90	13.2	21.9	17.6
120	13.9	20.9	17.4

Common practice has shown that because of the larger size of seed, durum wheat should be seeded at a heavier rate than is common for other spring wheats. The recommended rate is 105 pounds to the acre.

When Should Wheat Be Harvested?

Neither spring nor durum wheat should be harvested before the grain is in the dough stage. Numerous experiments have been made at University Farm and at other experiment stations to determine the desirability of early harvesting of wheat in seasons of severe rust epidemics. Altho premature cutting, when the kernels were in the milk, gave grain with bright color and luster, it also led to the production of some immature, shrivelled kernels and decreased weight per bushel. Cutting when the grain was firm gave a greater weight per bushel and higher yield than earlier harvesting. As a rule the grain should be in the dough stage before harvesting. There is no reason for premature harvest in years when stem rust is present.

Wheat can be cut with the binder when quite high in water content providing the grain is well shocked. Wheat should be harvested early to avoid possible losses from hail and stormy weather. Also, with large acreages it is necessary to start early in order to complete the harvest before the wheat is over-ripe. However, for straight combining, the water content must be reduced to about 14 per cent to prevent damage resulting from heating. Experiments have shown that where weeds are in the grain it is necessary to use a windrower in connection with the

combine. Furthermore, danger of hail and delay in fall work make the use of the windrower more practical than the straight combine, in the Red River Valley. Using this plan, the grain is cut at the usual time of binder harvest and left in windrows to dry. As soon as dry, a combine with pickup attachment gathers the grain from the windrow and completes the threshing operation. Farmers interested in using a combine should obtain a copy of the Minnesota bulletin dealing with combine problems in the Northwest.[3]

SPRING WHEAT IMPROVEMENT

No one variety of spring wheat is superior in all characters. As long as stem rust is a menace, it will be desirable to use rust-resistant varieties. Marquillo and Ceres have been placed on the list of varieties recommended for Minnesota farmers. Both have certain serious defects and experiments are under way to obtain new varieties that are more satisfactory in all particulars. Until such are available, Marquillo and Ceres will probably be the most desirable varieties for the Minnesota farmer to grow.

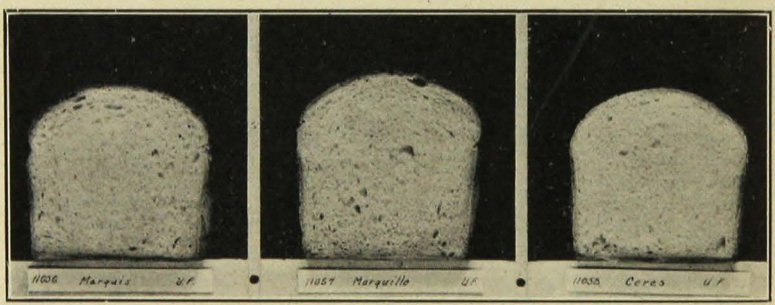

Fig. 4. Good Milling and Baking Qualities Are Necessary
From left to right, loaves of bread baked from Marquis, Marquillo, and Ceres wheat grown at University Farm.

Co-operative experiments between the spring wheat states, Minnesota, North Dakota, South Dakota, and Montana, and the United States Department of Agriculture are under way with the purpose of obtaining high quality spring wheats, resistant to all plant diseases prevalent in the spring wheat area and having desirable agronomic characters.

[3] Schwantes, et al. The Combine Harvester in Minnesota. Minn. Agr. Expt. Sta. Bull. 256. 1929.